Executive Summary

EPA's Science Advisory Board (SAB) created the Committee on Valuing the Protection of Ecological Systems and Services (C-VPESS) to offer advice to the Agency on how EPA might better assess the value of protecting ecological systems and services. As used in this report, the term "valuation" refers to the process of measuring values associated with a change in an ecosystem, its components, or the services it provides. The SAB charged the committee to:

- Assess EPA's needs for valuation to support decision making.
- Assess the state of the art and science of valuing the protection of ecological systems and services.
- Identify key areas for improving knowledge, methodologies, practice, and research at the Agency.

This report provides recommendations to the Agency for improving EPA's current approach to ecological valuation and for supporting new research to strengthen the science base for future valuations.

General findings and advice

EPA's mission to protect human health and the environment requires the Agency to understand and protect ecosystems and the numerous and varied services they provide. Ecosystems play a vital role in our lives, providing such services as water purification, flood protection, pollination, recreation, aesthetic satisfaction, and the control of diseases, pests, and climate. EPA's regulations, programs, and other actions, as well as the decisions of other agencies with which EPA partners, can affect ecosystem conditions and the flow of ecosystem services at a local, regional, national, or global scale. To date, however, policy analyses have typically focused on only a limited set of ecological factors.

Just as policy makers at EPA and elsewhere need information about how their actions might affect human health in order to make good decisions, they also need information about how ecosystems contribute to society's well-being and how contemplated actions might affect those contributions. Such information can also help inform the public about the need for ecosystem protection, the extent to which specific policy alternatives address that need, and the value of the protection.

Valuation of ecological systems and services is important in national rule makings, where executive orders often require cost-benefit analyses and several statutes require weighing of benefits and costs. Regional EPA offices can find valuation important in setting program priorities and in assisting other governmental and non-governmental organizations in choosing among environmental options and communicating the importance of their actions to the public. Ecological valuation can also help EPA to improve the remediation of hazardous waste sites and make other site-specific decisions.

This report describes and illustrates how EPA can use an "expanded and integrated approach" to ecological valuation. The proposed approach is "expanded" in seeking to assess and quantify a broader range of values than EPA has historically addressed and through consideration of a larger suite of valuation methods. The proposed approach is "integrated" in encouraging greater collaboration among a wide range of disciplines, including ecologists, economists, and other social and behavioral scientists, at each step of the valuation process.

Value is not a single, simple concept. People may use many different concepts of value when assessing the protection of ecosystems and their services. For this reason, the committee considered several value concepts. These included measures of value based on people's preferences for alternative goods and services (measures of attitudes or judgments, economic values, community-based values, and constructed preferences) and measures based on biophysical standards of potential public importance (such as biodiversity or energy flows).

To date, EPA has primarily sought to measure economic benefits, as required in many settings by statute or executive order. The report concludes that information based on some other concepts of value may also be a useful input into decisions affecting ecosystems, although members of the committee hold different views regarding the extent to which specific methods and concepts of values should be used in particular policy contexts.

In addition, the Agency's value assessments have often focused on those ecosystem services or components for which EPA has concluded that it could relatively easily measure economic benefits, rather than on those services or components that may ultimately be most important to society. Such a focus can diminish the relevance and impact of a value assessment. This report therefore advises the Agency to identify the services and components of likely importance to the public at an early stage of a valuation and then to focus on characterizing, measuring, and assessing the value of the responses of those services and components to EPA's actions.

EPA should seek to measure the values that people hold and would express if they were well informed about the relevant ecological and human well-being factors

involved. This report therefore advises EPA to explicitly incorporate that information into the valuation process when changes to ecosystems and ecosystem services are involved. Valuation surveys, for example, should provide relevant ecological information to survey respondents. Valuation questions should be framed in terms of services or changes that people understand and can value. Likewise, deliberative processes should convey relevant information to participants. The report also encourages EPA to consider public education efforts where gaps exist between public knowledge and scientific understanding of the contributions of ecological processes.

All steps in the valuation process, beginning with problem formulation and continuing through the characterization, representation, and measurement of values, require information and input from a wide variety of disciplines. Instead of ecologists, economists, and other social and behavioral scientists working independently, experts should collaborate throughout the process. Ecological models need to provide usable inputs for valuation, and valuation methods need to incorporate important ecological and biophysical effects.

Of course, EPA conducts ecological valuations within a set of institutional, legal, and practical constraints. These constraints include substantive directives, procedural requirements relating to timing and oversight, and resource limitations (both monetary and personnel). For example, the preparation of regulatory impact analyses (RIAs) for proposed regulations is subject to Office of Management and Budget (OMB) oversight and approval. OMB's Circular A-4 on *Regulatory Analysis* makes it clear that RIAs should include an economic analysis of the benefits and costs of proposed regulations conducted in accordance with the methods and procedures of standard welfare economics. At the same time, the circular provides that where EPA cannot quantify a benefit in monetary terms, EPA should still try to measure the effect of the Agency's action in terms of its physical units or, where such quantification is not possible, describe the effect and its value in qualitative terms. Regional and site-specific programs and decisions, which are not subject to the same legal requirements as national rule makings, can offer useful opportunities for testing and implementing a broader suite of valuation methods.

Three key recommendations

The committee's principal advice to EPA, as noted above, is to pursue an expanded, integrated approach to assessing the value of the ecological effects of its regulations, programs, and other actions. The report contains three overarching recommendations for achieving this goal. In particular, the report recommends that the Agency:

1. Identify early in the valuation process the ecological responses that are likely to be of greatest importance to people, using information about ecological importance, likely human and social consequences, and public concerns. EPA should then focus its valuation efforts on those responses. This will help expand the range of ecological responses that EPA characterizes or quantifies or for which it estimates values.
2. Predict ecological responses in terms that are relevant to valuation. Prediction of ecological responses is a key step in valuation efforts. To predict responses in value-relevant terms, EPA should focus on the effects of decisions on ecosystem services or other ecological features that are of direct concern to people. This, in turn, will require the Agency to go beyond merely predicting the biophysical effects of decisions and to map those effects to responses in ecosystem services or components that the public values.
3. Consider the use of a wider range of possible valuation methods, either to provide information about multiple sources and concepts of value or to better capture the full range of contributions stemming from ecosystem protection. In considering the use of different methods, however, care must be taken to ensure that only methods that meet appropriate validity and related criteria are used, and to recognize that different methods may measure different things and thus not be directly additive or comparable. This report therefore calls on EPA to develop criteria to evaluate and determine the appropriate use of each method. EPA should also carefully evaluate its use of value information collected at one site in the valuation of policy impacts at a different site (transfers of value information) and more fully characterize and communicate uncertainty for all valuations.

Implementing the recommendations

The report provides specific advice on how to achieve these overarching recommendations. The report proposes a large number of steps, some of which can be implemented in the short run, but others of which will require investments in research or method development, policy changes, and/or new resources. EPA should begin the process of adopting a more expanded, integrated approach to ecological valuation by prioritizing the steps that it will take to accomplish the report's recommendations, taking into account the relative ease and cost of each potential step.

Implementing recommendation #1

The first major recommendation, as noted, is to identify from an early stage in the valuation process the ecological responses that contribute to human well-being and are likely to be of greatest importance to people, and then to focus valuation efforts on these responses. To accomplish this, the report recommends that EPA:

- Begin each valuation by developing a conceptual model of the relevant ecosystem and the ecosystem services that it generates. This model should serve as a road map to guide the valuation.

- Involve staff throughout EPA, as well as outside experts in the biophysical and social sciences, in constructing the conceptual model.
- EPA should also seek information about relevant public concerns and needs. EPA can identify public concerns through a variety of methods, drawing on either existing knowledge or interactive processes designed to elicit public input.
- Incorporate new information into the model, in an iterative process, as the value assessment proceeds.

Implementing recommendation #2

Ecological valuation requires both prediction of ecological responses and an estimation of the value of those responses. To predict ecological responses in value-relevant terms, EPA should focus on the effects of decisions on ecosystem services and should map responses in ecological systems to responses in services or ecosystem components that the public can directly value. Unfortunately, the science needed to do this has been limited, presenting a barrier to effective valuation of ecological systems and services. To better predict ecological responses in value-relevant terms in the future, EPA should:

- Identify and develop measures of ecosystem services that are relevant to and directly useful for valuation. This will require increased interaction within EPA between natural and social scientists. In identifying and assessing the value of services, EPA should describe them in terms that are meaningful and understandable to the public.
- Where possible, use ecological production functions to estimate how effects on the structure and function of ecosystems, resulting from the actions of EPA or partnering agencies, will affect the provision of ecosystem services for which values can then be estimated. Development of a broad suite of ecological production functions currently faces numerous challenges and can benefit from new research.
- Where complete ecological production functions do not exist:
  - Examine available ecological indicators that are correlated with changes in ecosystem services to provide information about the effects of governmental actions on those services.
  - Use methods such as meta-analysis that can provide general information about key ecological relationships important in the valuation.
- Support all ecological valuations by ecological models and data sufficient to understand and estimate the likely ecological responses to the major alternatives being considered by decision makers. Analyze and report on the uncertainty involved in biophysical projections.

Implementing recommendation #3

In characterizing, measuring, or quantifying the value of ecological responses to actions by EPA or other agencies, EPA should consider the use of a broader suite of valuation methods than it has historically employed. As summarized in Table 3 at pages 42-43, this report considers the possible use of not only economic methods, but also such alternative methods as measures of attitudes, preferences, and intentions; civic valuation; decision science approaches; ecosystem benefit indicators, biophysical ranking methods; and cost as a proxy for value. A broader suite of methods could allow EPA to better capture the full range of contributions stemming from ecosystem protection and the multiple sources of value derived from ecosystems. Non-economic valuation methods may also usefully support and improve economic valuation by helping to identify the ecological responses that people care about, by providing indicators of economic benefits that EPA cannot monetize using economic valuation, and by offering supplemental information outside strict benefit-cost analysis. In this regard, EPA should:

- Pilot and evaluate the use of alternative methods where legally permissible and scientifically appropriate.
- Develop criteria to determine the suitability of alternative methods for use in specific decision contexts. An over-arching criterion should be validity – i.e., how well the method measures the underlying construct that it is intended to measure. Given differences in premises, goals, concerns, and external constraints, appropriate uses will vary among methods and contexts. Different methods are also at different stages of development and validation.

EPA could also improve its ecological valuations by carefully evaluating the transfer of value information and more fully characterizing and communicating uncertainty. In this regard, EPA should:

- Identify relevant criteria for determining the appropriateness of the transfer of value information. These criteria should consider similarities and differences in societal preferences and the nature of the biophysical systems between the study site and the policy site. Using these criteria, EPA analysts and those providing oversight should flag problematic transfers and clarify assumptions and limitations of the study-site results.
- Go beyond simple sensitivity analysis in assessing uncertainty, and make greater use of approaches, such as Monte Carlo analysis, that provide more useful and appropriate characterizations of uncertainty in complex contexts such as ecological valuation.
- Provide information to decision makers and the public about the level of uncertainty involved in ecological valuation efforts. EPA should not relegate uncertainty

analyses to appendices but should ensure that a summary of uncertainty is given as much prominence as the valuation estimate itself, with careful attention to how recipients are likely to understand the uncertainties. EPA should also explain qualitatively any limitations in the uncertainty analysis.

While EPA should improve its characterization and reporting of uncertainty, the mere existence of uncertainty should not be an excuse for delaying actions where the benefits of immediate action outweigh the value of attempting to further reduce the uncertainty Some uncertainty will always exist.

Context-specific recommendations

The report also examines how to implement an expanded and integrated approach to ecological valuation in three specific contexts: national rule makings, regional partnerships, and local site-specific decisions.

National rule making

Applying the expanded and integrated valuation approach to national rule making will entail some challenges, but also offers important opportunities for improvement. EPA can implement some, but not all, of the committee's recommendations using the existing knowledge base. The committee also recognizes that EPA must conduct valuations for national rule making in compliance with statutory and executive mandates. Specific recommendations for improving valuations for national rule making in the short run include:

- EPA should develop a conceptual model at the beginning of each valuation, as discussed above, to serve as a guide or road map. To ensure that the model captures the ecological properties and services that are potentially important to people, EPA should incorporate input both from relevant science and about public preferences and concerns.
- The Agency should address site-specific variability in the impact of a rule by producing case studies for important ecosystem types and then aggregating across the studies where information about the distribution of ecosystem types and affected populations is available.
- EPA should not compromise the quality of its valuations by inappropriately transferring information about values. Where the values of ecosystem services are primarily local, the Agency can rely on scientifically-sound value transfers using prior valuations at the local level. However, for services valued more broadly, EPA should draw from studies with broad geographical coverage (in terms of both the changes that are valued and the population whose values are assessed).
- EPA should pilot and evaluate the use of a broader suite of valuation methods to support and improve RIAs. Although OMB Circular A-4 requires RIAs to monetize benefits to the extent possible using economic valuation methods, other methods could be useful in the following ways:
  - Helping to identify early in the process the ecosystem services that are likely to be of concern to the public and that should therefore be the focus of the benefit-cost analysis.
  - Addressing the requirement in Circular A-4 to provide quantitative or qualitative information about the possible magnitude of benefits (and costs) when they cannot be monetized using economic valuation.
  - Providing supplemental information outside the formal benefit-cost analysis about sources and concepts of value that might be of interest to EPA and the public but not reflected in economic values.
- To ensure that RIAs do not inappropriately focus only on impacts that have been monetized, EPA should also report on other ecological impacts in appropriate units where possible, as required by Circular A-4. The Agency should label aggregate monetized economic benefits as "total economic benefits that could be monetized," not as "total benefits."
- EPA should include a separate chapter on uncertainty characterization in each RIA or value assessment.

Regional partnerships

The committee sees great potential in undertaking a comprehensive and systematic approach to estimating the value of protecting ecosystems and services at a regional scale, in part because of the effectiveness with which EPA regional offices can partner with other agencies and state and local governments. Regional-scale analyses hold great potential to inform decision makers and the public about the value of protecting ecosystems and services, but this potential is at present largely unrealized. The general recommendations of this report provide a guide for regional valuations. Regional valuations are a particularly appropriate setting in which to test alternative valuation methods because there are generally fewer legal directives or restrictions regarding the value concepts and methods to be used. The report also includes several recommendations specific to regions, including:

- EPA should encourage its regions to engage in valuation efforts to support decision making both by the regions and by partnering governmental agencies.
- EPA should provide adequate resources to EPA regional staff to develop the expertise needed to undertake comprehensive and systematic studies of the value of protecting ecosystems and services.
- To ensure that regions can learn from valuation efforts by other regions, EPA regional offices should

document valuation efforts and share them with other regional offices, EPA's National Center for Environmental Economics, and EPA's Office of Research and Development.

Site-specific decisions

Incorporation of ecological valuation into local decisions about the remediation and redevelopment of contaminated sites can help enhance the ecosystem services provided by such sites in the long run and thus the sites' contributions to local well-being. The general recommendations of the report provide a useful guide for such site-specific valuations. The report also includes several recommendations of particular relevance to site-specific decisions, including:

- EPA should provide regional offices with the staff and resources needed to effectively incorporate ecological valuation into the remediation and redevelopment of contaminated sites.
- EPA should determine the ecosystem services and values important to the community and affected parties at the beginning of the remediation and redevelopment process.
- EPA should adapt current ecological risk assessment practices to incorporate ecological production functions and predict the effects of remediation and redevelopment options on ecosystem services.
- EPA should communicate information about ecosystem services in discussing options for remediation and redevelopment with the public and affected parties.
- EPA should create formal systems and processes to foster information-sharing about ecological valuations at different sites.

Recommendations for research and data sharing

The report provides several recommendations for EPA's research programs that are designed to provide the ecological information needed for valuation, develop and test valuation methods, and share data. In a number of cases, these recommendations parallel research plans that have been developed by the Office of Research and Development and other Agency groups. As an over-arching recommendation, the report advises EPA to more closely coordinate its research programs on the valuation of ecosystem services and to develop links with other governmental agencies and organizations engaged in valuation and valuation research. It advises, at a more general level, fostering greater interaction between natural scientists and social scientists in identifying relevant ecosystem services and developing and implementing processes for measuring them and estimating their value. The report identifies important research areas but does not attempt to rank or prioritize among all of its research recommendations. The committee recommends that EPA develop a research strategy, building on the recommendations in this report, that identifies "low-hanging fruit" and prioritizes studies likely to have the largest payoff for their cost in both advancing valuation methods and providing valuation information of importance to EPA in its work.

To develop EPA's ability to determine and quantify ecological responses to governmental decisions, the Agency should:

- Support the development of quantitative ecosystem models and baseline data on ecological stressors and ecosystem service flows that can support valuation efforts at the local, regional, national, and global levels.
- Promote efforts to collect data that can be used to parameterize ecological models for site-specific analysis and case studies or that can be transferred or scaled to other contexts.
- Carefully plan and actively pursue research to develop and generate ecological production functions for valuation, including Office of Research and Development and STAR research on ecological services and support for modeling and methods development. The committee believes that this is a research area of high priority.
- Given the complexity of developing and using complete ecological production functions, continue and accelerate research to develop key indicators for use in ecological valuation. Such indicators should meet ecological and social science criteria for effectively simplifying and synthesizing underlying complexity and link to an effective monitoring and reporting program.

To develop EPA's capabilities for estimating the value of ecological responses to governmental decisions, EPA should:

- Support new studies and the development of new methodologies that will enhance the future transfer of value information and other means of generalizing ecological value assessments, particularly at the national level. Such research should include national surveys related to ecosystem services with broad (rather than localized) implications so that value estimates might be usable in multiple rule-making contexts. This should also be a priority area for research.
- Invest in research designed to reduce uncertainties associated with ecological valuation through data collection, improvements in measurement, theory building, and theory validation.
- Incorporate the research needs of regional offices for systematic valuation studies in future calls by EPA for extramural ecological valuation research proposals.

To access and share information to enhance the Agency's capabilities for ecological valuation, EPA should:

- Work with other federal agencies and scientific organizations such as the National Science Foundation to encourage the sharing of ecological data and the development of more consistent ecological measures that are useful for valuation purposes. A number of governmental organizations, such as the United States Department of Agriculture and the Fish & Wildlife Service, are working on biophysical modeling and valuation, and EPA could usefully partner with them.
- Support efforts to develop Web-based databases of existing valuation studies that could be used in transferring value information. The databases should include valuation studies across a range of ecosystems and ecosystem services. The databases should also carefully describe the characteristics and assumptions of each study, in order to increase the likelihood that those studies most comparable to new valuations can be identified for use.
- Support the development of national-level databases of information useful in the development of new valuation studies. Such information should include data on the joint distribution of ecosystem and human population characteristics that are important determinants of the value of ecosystem services.
- Develop processes and information resources so that EPA staff in one region or office of the Agency can learn effectively from valuation efforts being undertaken elsewhere within the Agency.